E/CONF.39/A/199
29 Oct.1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item : A. 3. 4. 1

Australia

USE OF SIMPLE EARTH-MOVING TECHNIQUES TO COLLECT AND CONSERVE SEASONAL WATER FLOWS

By H. J. GEDDES,
University of Sydney,
Australia

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

USE OF SIMPLE EARTH-MOVING TECHNIQUES TO COLLECT AND CONSERVE SEASONAL WATER FLOWS

by H.J. Geddes, University of Sydney, Australia.

1. Over the past ten years the Animal Husbandry Department of the University of Sydney has been investigating the practicability and the economics of a system of irrigation, called "water harvesting", which obtains its water supplies by collecting and storing the farm run-off.

2. The work had its genesis in an experience in 1952 when a small field of subterranean clover, irrigated from a farm dam, gave a gross return of £A174 worth of milk to the acre. The 400-ac farm is in the centre of the County of Cumberland, a quarter-million acre belt of farming land separating the city of Sydney from the Blue Mountains 40 miles away. Although settled for 170 years, this land, owing to the extreme variability of the rainfall, is still largely undeveloped. There is no regular pattern of rainfall and the farming belt lies in a rain shadow. Along the coast the average is 47 in, thirty miles inland 26 in. The only constant feature is a tendency towards two heavy falls, of 5 or 6 in each, in most years.

3. The 1952 experience stimulated interest in the possibility of collecting for irrigation the run-off of these deluges. No alternative source was available. Underground waters were too deep and too salty. There were no springs and no nearby permanent streams. The initial questions were whether supply got by collecting farm run-off would be adequate and reliable for irrigation; and whether the storage of irrigation water on the farm would be economical.

4. It so happened that the area offered an unusually favourable combination of circumstances for the economic storage of irrigation water: the impervious subsoil, a heavy clay, provided excellent structural material for embankments; the nature of the rainfall ensured a fairly high rate of run-off (a study of 70 years previously had suggested the run-off of the watershed of the Nepean - Hawkesbury river system, which drained the area, was 39% of the rainfall); and the gently undulating nature of the countryside provided a large number of economic sites for dams. Rainfall studies indicated that although the annual precipitation had varied from 66 to 12 in with an average of 26 in, there were few years in which no heavy falls occurred. If the run-off of the farm were actually 39% the expected water yield of the 400 acres would be 90,000,000 imperial gallons a year, or 304 ac ft.

5. The basis of economic storage in a farm dam is a high ratio of storage to excavation. A wholly excavated storage, such as a surface

tank, accommodates a cubic yard of water for each yard of excavation. A dam across a valley on the other hand, obtains additional storage capacity as the wall backs the water out beyond the excavation. The storage excavation ratio is closely related to the slope of the valley floor; the flatter the valley floor the cheaper the cost of storage. Since most valleys tend to become progressively less steep from top to bottom, more economic storage is likely in their lower than in the upper reaches. On the other hand, the structural material in the lower reaches is more likely to be alluvial and, therefore, less suitable for construction of an impervious wall. Most of the early dams built in this scheme had a storage:excavation ratio of 5 or 6.

6. Poor consolidation of the first dams built with a bulldozer led to the use of wheeled scoops. These also carried clay from the valley sides into the centre of the bank more cheaply.

7. No new practices were involved in the construction of dams, but particular care was taken to get the core trench down into the clay subsoil and to backfill with impervious soil to prevent losses by seepage through the wall. Adequate by-wash or overflow capacity is essential to protect the embankment against over-topping during a storm. The driver of the earth-moving machine needs to understand the strategy of economic operation. The unskilled waste time and money by unnecessary movement of the earth.

8. The University Farm at Badgery's Creek, on which this work was done, has been progressively developed as the water storage was increased. The aerial photograph (Figure I) depicts the storage system as it is to-day. Total capacity, of the 14 dams and the two tanks, is 56,000,000 gal or 203 ac ft. If a further 2 dams were constructed it would become 70,000,000 gal or 260 ac ft. The capital cost of storage has been considerably less than that of the larger storages which supply the public irrigation schemes.

9. Extensive use has been made of contour drains, or rather drains on the critical gradient of 1 in 200, to collect run-off and divert it into storages. By these drains the whole farm has become a catchment. On rolling country dams can store the run-off economically. Flat country, however, presents two problems: that of securing a supply of water, that of economic storage.

10. The answer to the first lies in the use of storm-water creeks, which intersect some of the flat land. The storm-water creeks were not initially encouraging. They ran for only a few days a year. Certainly they carried huge volumes of water in that time, but it soon disappeared and was not available when it was needed - in a dry time. Such creeks seldom lend themselves to damming. Their beds are usually too small in cross-section to hold a worth-while quantity of water. The pace of the flood is often so great that an earthen wall would not hold; concrete walls cost 20 times as much as earther. It was clear that the only way to utilize these creeks was to pump the water out of them at the peak of the storm and that would only work if the second basic problem of economic storage on flat ground could be solved and the water pumped at a reasonable cost. An investigation of pumping costs brought to light an interesting figure, namely, that it was possible to lift an acre-foot of water one foot in height for less than a shillingsworth of diesel power. This basic figure indicated that the cost of pumping water from a storm-water creek into a storage system would not be excessive.

11. The answer to the second problem, that of economic storage, was found in the so-called "turkey nest" tank.
(a) Turkey nest tanks have been built for many years in Queensland and north-western New South Wales. They take the form of a ring embankment built entirely above ground, using some of the earth removed in excavating a big sunken tank alongside. The sunken tank is the major storage; the purpose of the turkey nest being to provide a gravity feed to the water trough. It merely replaces a galvanized tank on a stand, being filled by a windmill from the sunken tank. A pipe through the wall carries the water to the troughs. These turkey nests are not large, perhaps 15 to 20 yards in diameter at the most.
(b) Where used for irrigation water, the turkey nest tank is filled from the nearby seasonally flowing stream which in effect, takes the place of the underground tank alongside the traditional stock watering turkey nest.
(c) A characteristic feature of the turkey nest is that the cost of storage diminishes with unnecessary diameter; doubling the diameter cuts the cost of storage in half. The first turkey nest built on the farm had a capacity of 8,500,000 gal - about 31 ac ft - covered 4 ac, was 150 yards in diameter, had an average depth of 8 ft 8 in and stored 6½ cu yards of water for each yard of excavation. If one allows 5% interest on the capital cost of £A21 an acre-foot, the annual interest charge on the water stored in the turkey nest was 21 shillings an acre-foot. If circumstances allowed filling and emptying twice a year this cost would be halved. As the lift was eleven feet, the filling cost was 11 shillings per acre-foot. The total cost of water stored in the turkey nest was, therefore, 32 shillings per acre-foot.
(d) The shallower the turkey nest the lower is the cost of storage. However, the deeper it is the lower the proportionate loss by evaporation. In practice a compromise must be made. The depth will also be decided by the frequency with which the turkey nest can be filled. When there are frequent and reasonably reliable opportunities for replenishment one could take advantage of the economy of a fairly shallow structure. If the opportunities are few and irregular a deeper tank must be built to secure a reasonable recovery of the water pumped into it. Several turkey nests have been built for irrigation purposes. The largest covers 30 ac and has a capacity of 67,000,000 gal or 250 ac ft.

12. Public acceptance of water harvesting is indicated by a recent census of the surrounding district; 75% of the dairy farmers are now irrigating compared with 2% before the advent of this work.

13. General adoption of the practice has been encouraged by the associated work on water utilization* which has succeeded in developing a farming regime which produces year-round grazing.
(a) Two out of the three University-owned dairy herds, engaged in town supply, have been carried for 25 months on grazing without the necessity to resort to concentrate feeding at any time. The only other feed provided has been a small quantity of pasture hay - an by-product of the farming regime.
(b) In summer the herds are carried on an irrigated pasture of paspalum and white clover at the rate of two cows per acre. Winter grazing is provided by sod-seeding oats at the rate of four bushels

---

* Crofts, F.C., Carter, O.G. and Geddes, H.J., The practice of planned pasture production and utilization, Syd. Univ. School of Agric. Agron. Bull. No. 3 (1960).

per acre into the pasture with 80 lb of nitrogen per acre. The area required to carry the herd through the winter months is one acre per cow.

(c) The area under irrigation is varied inversely with the seasonal productivity of the feed. This has distinct management advantages: in winter when the pace of watering is least the larger area can be handled without stress; in summer, when waterings must be frequent, the smaller area can be handled without any greater effort. Greater economy in irrigation plant is possible: the spray line that served 40 ac in summer can serve 80 ac in winter when the time available to get the watering done is twice as long; the only added cost is the extra length of irrigation main to command the larger area.

Figure 1 - Aerial photograph of the University Farm at Badgery's Creek showing storage system

1412 E - Nov. 1962